ExpeER

Distributed Infrastructure for EXPErimentation in Ecosystem Research

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SEVENTH FRAMEWORK PROGRAMME

Capacities

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Theme: Environment and Earth Sciences

DELIVERABLE D 1.3

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"A roadmap for European ecosystem research infrastructure"

Abstract:

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Table of Contents

Glossary

DOW: Description of work

WP: Work package, see description of work (DOW) of the EXPEER project

TA: Transnational Access

HIES: Highly instrumented experimental site

HIOS: Highly instrumented observational site

NEON: National Ecological Observatory Network

ICOS: Integrated carbon observation system

ANAEE: Analysis and Experimentation on Ecosystems

LTER-Europe: Long-term Ecosystem Research Network in Europe

MCDA: Multi-Criteria Decision Analysis

1. Executive summary

The ExpeER research network includes four types of research infrastructure distributed across 33 facilities within 13 European countries. These include both Highly Instrumented Experimental and Observational Sites (HIES & HIOS, 29), Analytical Facilities (2) and Ecotrons (2), which provide state of the art analytical equipment and controlled environment facilities for ecosystem research. In an earlier report, the extent of the research capability at each site was evaluated using a questionnaire concerning information on the ecosystems under study, the main research disciplines employed (e.g. meteorology, biogeochemistry, hydrology, atmospheric chemistry etc.), and the technical services available at 29 of the 33 facilities. During the ExpeER WP1 workshop held in Leipzig from February 21-24, 2012 it was decided to modify the site questionnaire in order to obtain more detailed information from site managers, which could be used to help identify areas for development as part of a future roadmap. An analysis of the information provided by 30 of the 33 initial sites is presented in the revised deliverable D1.1 together with the new radial diagrams generated from the additional information obtained.

A detailed examination of the site details indicated that many sites have good technical services and conduct a broad range of meteorological and soil measurements, but many were lacking in laboratory space for collaborative work. There was clear scope to enhance the capacity of most sites with respect to the extent of the experimental manipulations studied in their work and to increase the range of measurements within studies on hydrology, local atmosphere and biodiversity. There also appeared to be a bias in favour of studies on autotrophic organisms (mostly plants) compared with heterotrophic communities.

Two principle approaches are proposed to facilitate improvements in the scientific capacities of the sites and enhance future collaborations. Firstly, general improvements could be facilitated by national investment in facilities and expertise within all ExpeER sites to enhance the capacities as identified above. Alternatively, sites with a similar scientific focus (e.g. biodiversity, hydrology, local atmosphere etc.) could be identified as sub-groups within ExpeER to encourage future collaborative work within their areas of expertise. National resources could then be targeted in these areas to increase the extent and quality of future collaborations. Such collaborations could be further enhanced by EU thematic research programmes designed to support research within these areas. The provision of more laboratory space was identified as a general requirement for most sites. Consequently, this is an important priority to address if ExpeER is to enhance international scientific collaboration and create synergies that can help achieve its vision of an integrated European research infrastructure.

General improvements could be facilitated by national or European investment in facilities and expertise within all ExpeER sites to enhance their scientific capacities. Alternatively, sub-groups with similar areas of expertise (e.g. biodiversity, hydrology, local atmosphere etc) within ExpeER could develop future collaborative work within these areas. An important priority for ExpeER to address to enhance international scientific collaboration and create synergies that can help achieve its vision of an integrated European research infrastructure. Ecotrons should provide a facility at such an advanced level, but they cannot exist in every country. The total capacity however might require similar features of some of these ecotrons. New and existing ecotrons should be complimentary. Improved systems for effective sharing of data to ensure availability, consistency of data including data format, and incentives for making sure new data are included in sharing systems. Incentives for continuous technological upgrade of selected facilities. Coordinated funding mechanisms between EU and individual nations. Funding and administrative mechanisms which promote international collaboration at the distributed research infrastructure.

2. Introduction

2.1 Background

Climate change, land-use change and biodiversity loss are major drivers behind many current environmental problems resulting from increased human pressure towards the Earth's ecosystems. This is mainly due to the human society living well beyond the carrying capacity of the planet, exerting evermore pressure on our natural environment with irreversible consequences (Rockström *et al.* 2009, Barnosky *et al.* 2012). At a global level, it is estimated that nearly two thirds of ecosystem services have been degraded in just fifty years (Millenium Ecosystem Assessment 2005), and the additional stress imposed by climate change will require extraordinary adaptation that will vary depending on the geographical location of ecosystems (e.g. Mooney *et al.* 2009, Forsius *et al.* 2013).

For any experimental or observational field site, good monitoring systems for natural conditions are required, the minimum being meteorological data. Next might be to consider the system characterisation and monitoring system, here there will often be a divergence among the different sites depending on the focus of the researchers who originally designed the field site, for example the focus could have been biodiversity, soil chemistry, flow and transport processes. The initial focus may be reflected in the radial diagrams shown in Deliverable D1.1. When the full ecosystem is considered however, we cannot isolate these different areas of research as separate units. To understand the full dynamics of an ecosystem we need; the meteorological conditions, the hydrological conditions, surface and subsurface water and temperature, the chemical composition of rain as well as subsurface water, and the bio-geo-chemical conditions of the site, including flora and fauna. The control of gaseous fluxes and concentrations above and below ground are also important. Other factors that need to be considered are dry deposition, nutrient balance, carbon balance, yield, composition and dynamics of vegetation above and below the ground etc. This point is discussed further in the next section where we discuss the areas for future development identified by the ExpeER site managers. For the system characterisation we can consider the number of parameters or variables that are included, but factors such as spatial coverage in relation to size of site and temporal resolution are factors that indicate quality of the sites. In short, the quality of a site lies in the potential of the data collected at the site to be used to calibrate and validate process based models. For experimental sites, the number of possible manipulations and the monitoring and control of these will be important for the evaluation of their performance and ‘fingerprint’ of the research emphasis of the different ExpeER field sites (see D1.1).

2.2 Objective

The objective of the work towards Deliverable D1.3 is to define a roadmap for the EXPEER infrastructure which reduces current gaps, promotes complementarities, synergies and upgrading. The overall capabilities of the ExpeER facilities for ecosystems research was identified through the work done in the revised version of deliverable D1.1. Factors such as climatic and geographic zones, types of ecosystems, spatiotemporal resolution, services provided and data availability was mapped through questionnaires and field visits. Based on these results, and the capacity to provide sufficient data for the models used in the ExpeER project (WP9 and WP10), additional measurements are suggested. In addition, based on gaps identified and improvements suggested, a transparent structure of how a combined use of different components can improve sites for experimental work and enhance the interpretation of existing data series is outlined. The roadmap also suggests better ways to integrate the different work components to reduce the costs and investment for each individual component.

In addition to this report, results from the analyses presented in D1.1 and here (D1.3) will be integrated in the ExpeER website to improve the transparency of infrastructure capabilities, increase communication, collaboration and visibility of complementarities.

The objective of this report is to present an analysis of the information provided in the new questionnaires and, based on this analysis, to outline an action plan for further research and infrastructure developments to create a more integrated European ecosystem research network. The ultimate aim being to reduce gaps and create synergies that can help achieve ExpeER's vision of an integrated European research infrastructure. The report gives recommendations to enhance scientific quality and facilitate improved collaboration between the ExpeER research sites.

3. Site information and analysis

3.1 The new questionnaires

In order for ExpeER to characterise each site as accurately as possible and to highlight both its strengths and areas for development, site managers were asked to provide as much information as possible. During the ExpeER WP1 workshop in Leipzig in February 2012 revised questionnaires were sent out and by September 2013, 30 completed questionnaires had been returned to ExpeER. The information provided was used to generate new radial diagrams for these sites (see Appendix A3 of D1.1) and the new diagrams were sent to all site managers for review and comments. Two out of the 33 initial sites have either been closed or are not in the project any more.

3.2 Data analysis

A more detailed analysis of the ExpeER site capacities was done using information obtained from the revised questionnaires returned by 30 of the 33 initial sites. The aim of this analysis was to develop a better understanding of the nature of the work being done within the ExpeER sites, with a view to identifying areas to target for improvement and identify sites for future collaborative work, as part of a future roadmap. The numbers of sites with specific capacities, or carrying out specific measurements, within the main categories (Technical services, Meteorology etc.) identified in the revised questionnaires were quantified using the information provided. These analyses are summarised below.

Technical services

The feedback obtained indicated that basic services (water and power) are available at most of the sites (Fig 1). In most cases local accommodation is available for visiting researchers, but laboratory space is available in only about half of these. Many sites have sample archive facilities and some have modelling capacity. However, in most cases local access restrictions apply, indicating that permission to sample fresh or archived samples and/or data is required before site access to visitors is granted. Other capacities with low score are the NIRS database (near surface infra red spectroscopy) and modelling platforms. To be able to transfer knowledge from one location to another as well as between scales, modelling is of key importance. As a minimum the hydrological part of any field site or laboratory experiment should be modelled at some level. WP 9 provides examples of some available models, and will by the end of the project have tested some at the ExpeER sites (Lusignan, Fr and Plynlimon, UK) as well as some other European field sites. At a number of sites the available data for testing these models were not sufficient, highlighting the importance of conducting such modelling studies in order to reveal data gaps at the different sites. A modeling tool box has been developed by WP9 which guides users on selection of models, how to set up the model and which model outputs. The plan is also to provide global datasets for Europe and a parameter library which can be used in cases where in-situ measurements and parameters do not exist.

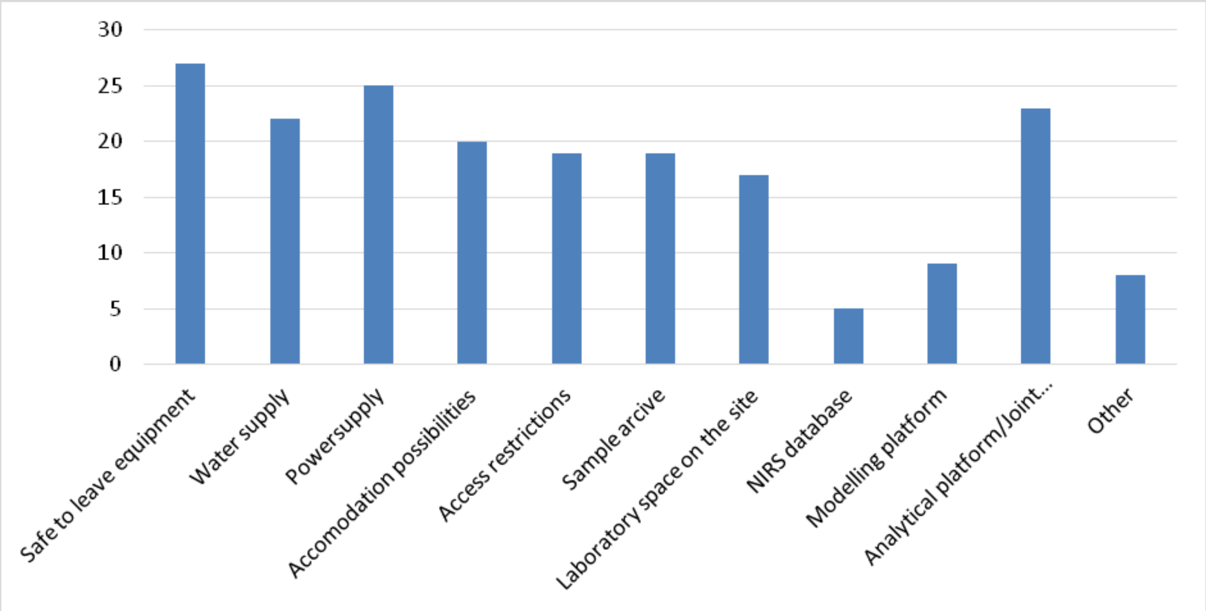


Figure 1. Number of ExpeER sites with different technical services (NIRS: near infra red spectroscopy)

Meteorology

Almost all sites monitor basic meteorological parameters, including air temperature, humidity, rainfall and wind speed. A good many other parameters are recorded at most sites (Fig 2), but less than half record ground temperature, net solar radiation, net far radiation, diffuse solar radiation, sky temperature, UV radiation and other variables.

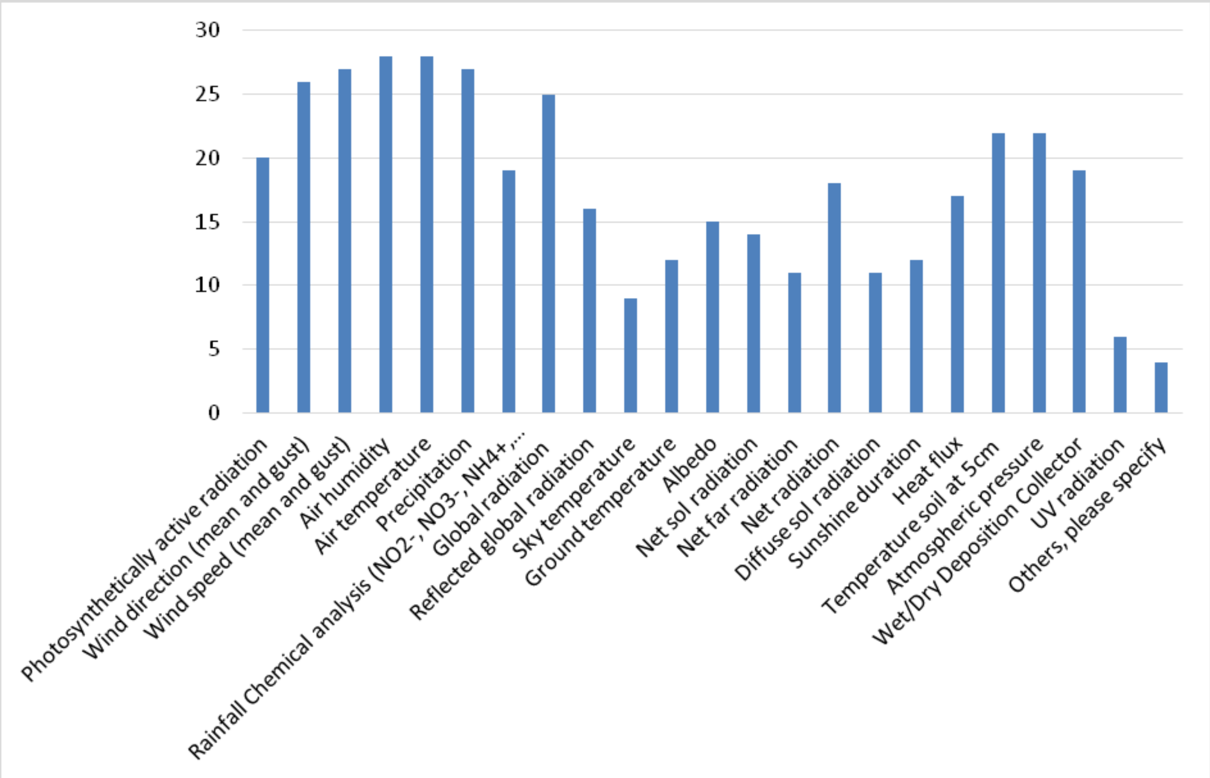


Figure 2. Number of ExpeER site with different meteorological (local) measurements

Manipulations

An analysis of the experimental manipulations imposed at the 30 ExpeER sites indicated that there were few sites with highly manipulative experiments. The data indicate that landuse, irrigation/drought, soil management (e.g. cultivations) and fertiliser/manure applications were the most common experimental treatments imposed at the sites (Fig 3). Less common were manipulations of atmospheric variables, biodiversity, temperature and drainage; no manipulations of ozone, salinity or radiation (light) were evident. This preliminary analysis indicates that there is scope to increase the number of manipulative experiments across the ExpeER network, even for the most commonly studied treatments (landuse, irrigation, soil management etc).

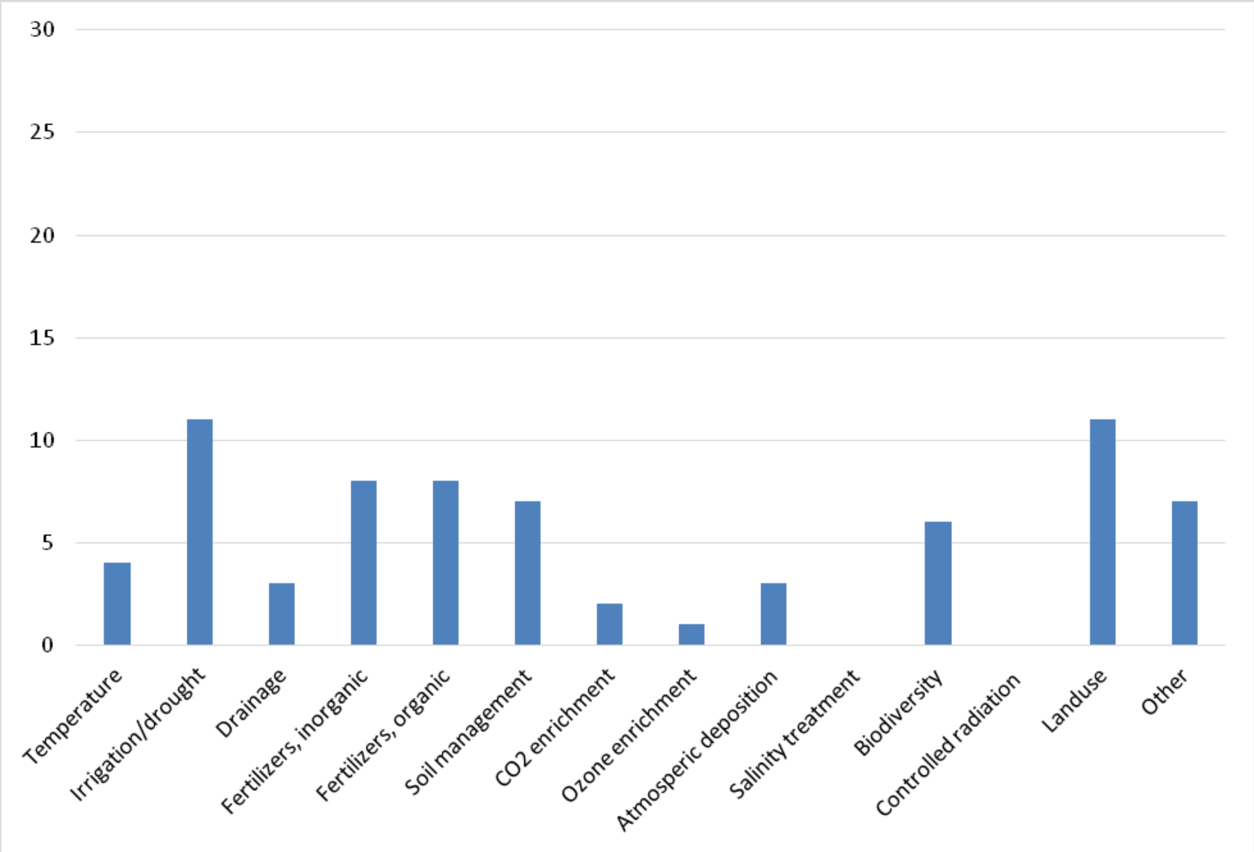


Figure 3. Number of ExpER site with different manipulation possibilities. Controlled radiation includes light intensity and spectrum treatment, lamp type.

Soils

Most sites measured key soil parameters, e.g. soil type, texture, chemical composition, bulk density, moisture, soil solution composition and temperature (Fig. 4), but others were less common, such as hydraulic conductivity, soil enzymes, lipids and lignin etc. A set of standard and minimum measurements should be defined. For some properties such as the hydraulic conductivity, soil texture can be used to estimate this value from pedotransfer functions. The more pedotransfer functions are required to get a complete description of the local system (e.g. for hydrological modelling) the more uncertain the state variables describing the system will be, this uncertainty will again influence any transfer of knowledge between locations and scales reducing our overall capabilities of understanding how ecosystems will respond to changes in land use, climate etc.

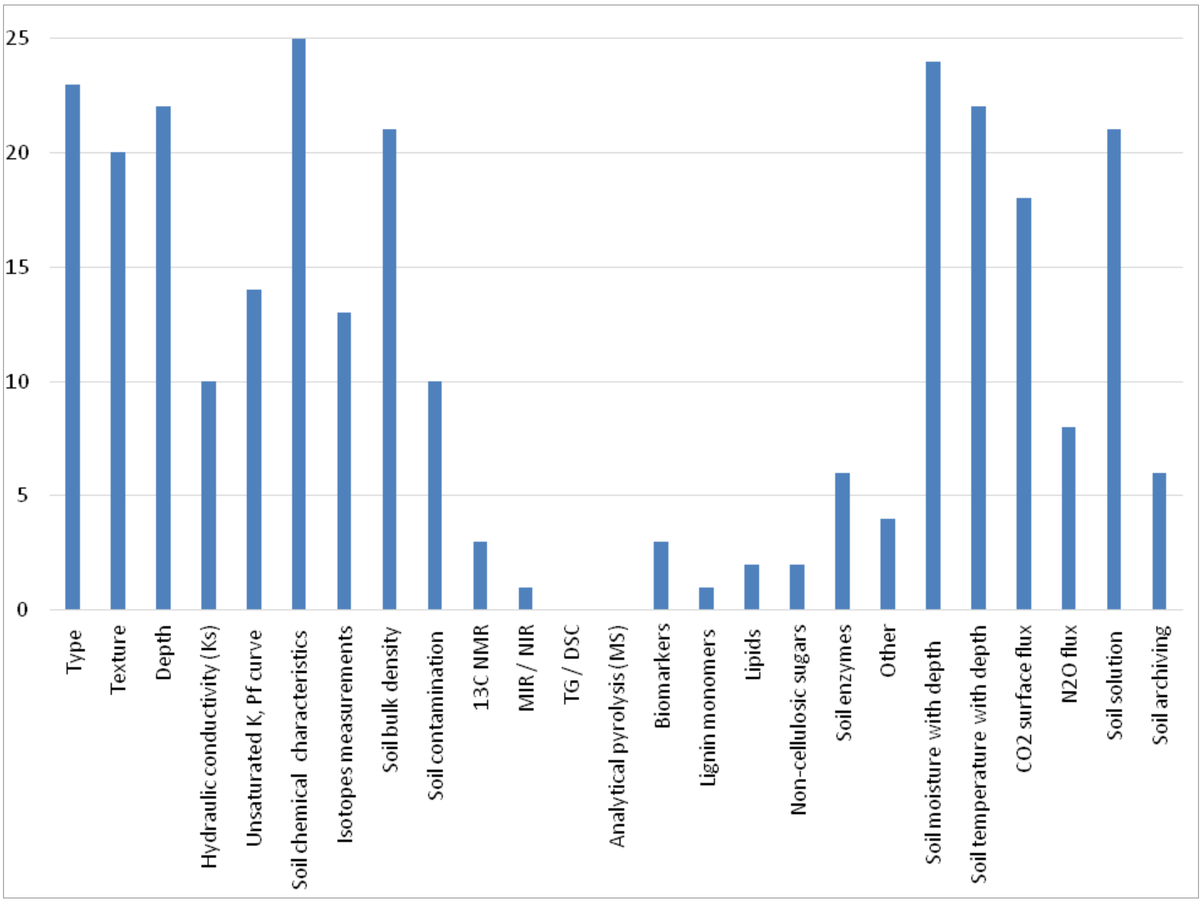


Figure 4. ExpeER site soil (local) measurements, Additional information to the X-axis; Soil chemical characteristics (pH, CEC, EC, C and N content, …), Isotopes measurements (Delta ^{13}C measurement, Delta ^{15}N measurement, ^{14}C age, specify) Soil contamination (N deposition, ash deposition, heavy metal), Soil solution sampling and measurements: DOC, DON, P, K, Ca, Mg, Na, Cl

Hydrology

More than half the sites monitor soil water quality, but less than half measure groundwater parameters and surface runoff (Fig 5). Consequently, there is significant potential for improvements in site infrastructures in this area.

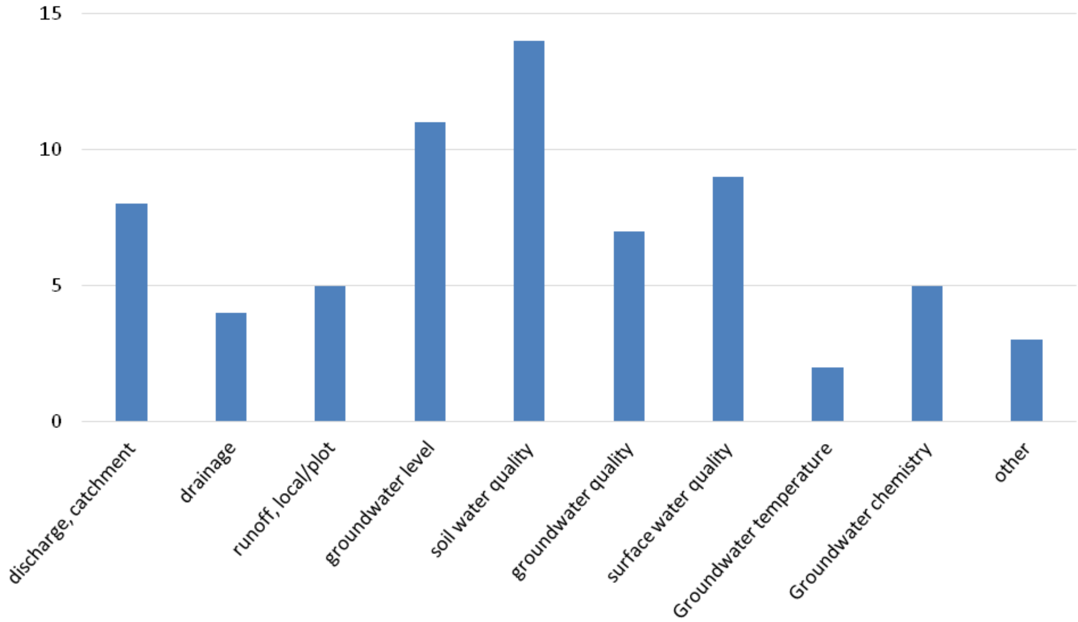


Figure 5. Number of ExpeER site with different hydrological (local) measurements, Groundwater chemistry includes: DOC, DON, P, K, Ca, Mg, Na, Cl

Local atmosphere

About half of the responding sites measure N deposition (wet and dry), humidity, temperature, global radiation and PAR, but measurements of ozone, through-fall and gaseous fluxes are rarer (Fig 6). Rarer still are measurements of stable isotopes (^{13}C & ^{18}O), which are studied at only two of the 18 sites. For climate change research these variable are highly relevant and can truly help validate estimates of earth responses and feed-back mechanisms as a function of climate change. The present analysis of EXPEER facilities reveals a great need to increase this capacity at the examined facilities, and for close collaboration with other infrastructure projects such as ICOS.

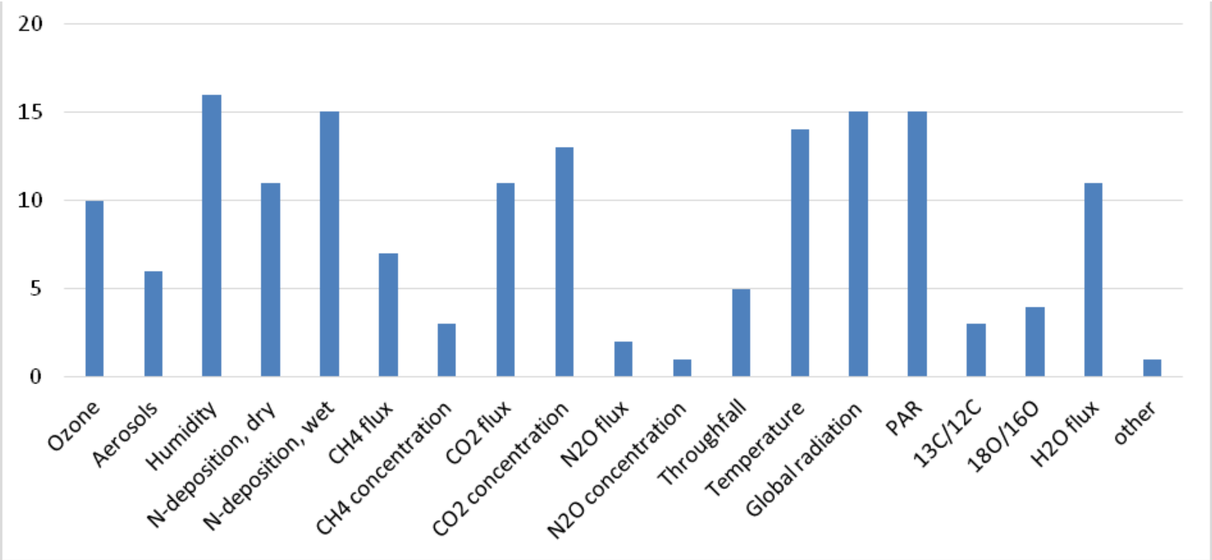


Figure 6. Number of ExpeER site with different atmospheric (local) measurements

Biodiversity

Biodiversity studies within the network were wide ranging, but often focussed on only a few species at each site. The most common species studied included vascular plants, insects, mosses and birds (Fig 7). Relatively few sites studied mycorrhiza, crustaceans and other arthropods; no studies on Rhizobia were recorded and there was only one food web study. There is clear scope for expanding the biodiversity studies at the ExpeER sites to include more work on macroalgae, mycorrhiza, annelida, crustaceans, athropods and food webs, but decisions as to which of these should be adopted at each site will depend largely on the nature of the sites in question and the scientific questions to be answered. Enhancing collaboration between sites and greater investment in local capacity (expertise & facilities) may help increase the breadth of species studied within the ExpeER sites.

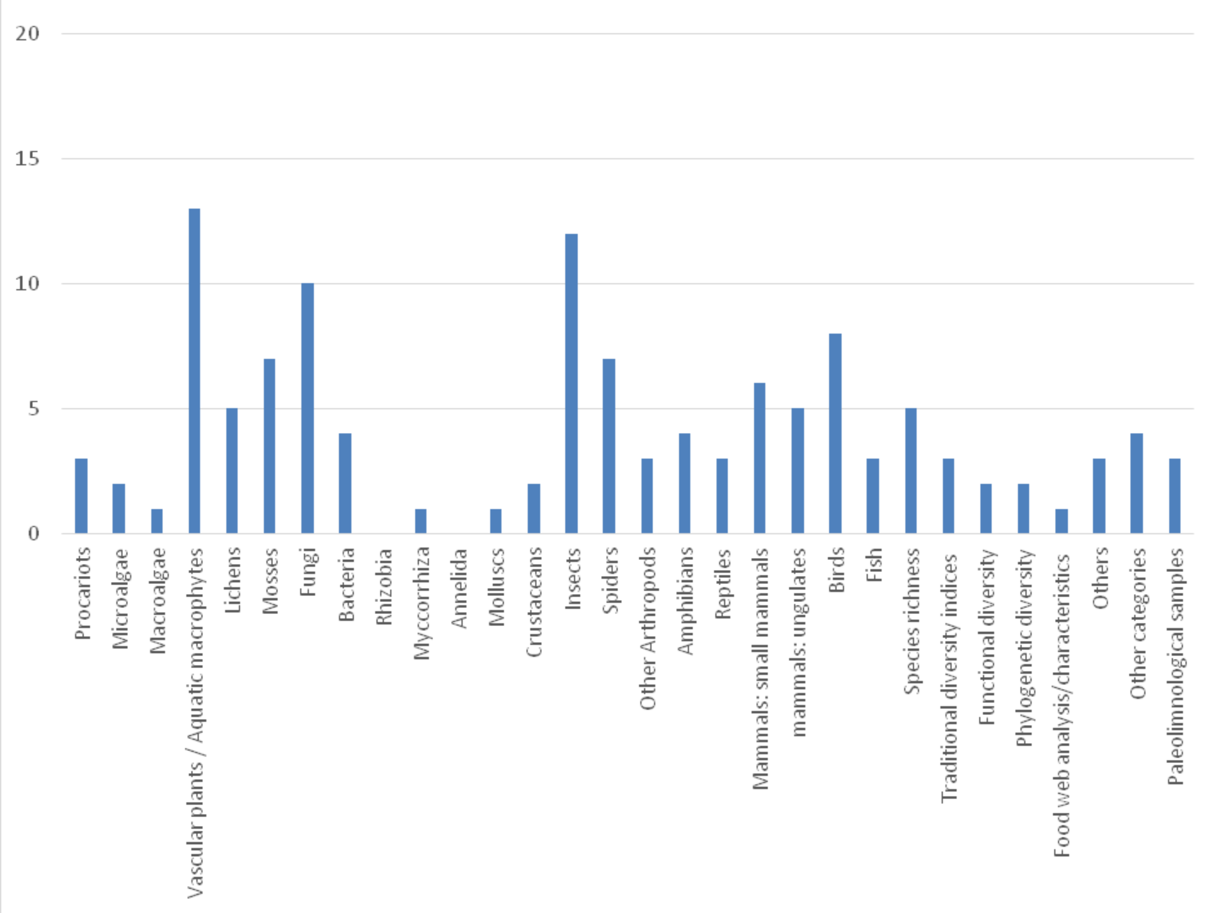


Figure 7. Number of ExpeER site with different biodiversity (local) measurements, Traditional diversity indices (e.g. Shannon, Simpson, etc.), Food web analysis/characteristics (length, connectivity, etc.), Other categories: Zooplancton, Meiofauna, Benthic macroinvert.

Autotrophic compartment

About half of the responding sites studied autotrophic organisms (mostly plants); measurements included abundance, biomass, production (including roots) and leaf area (Fig 8). Some sites included studies on phenology, plant canopy and vegetation cover, but species specific studies were less common.

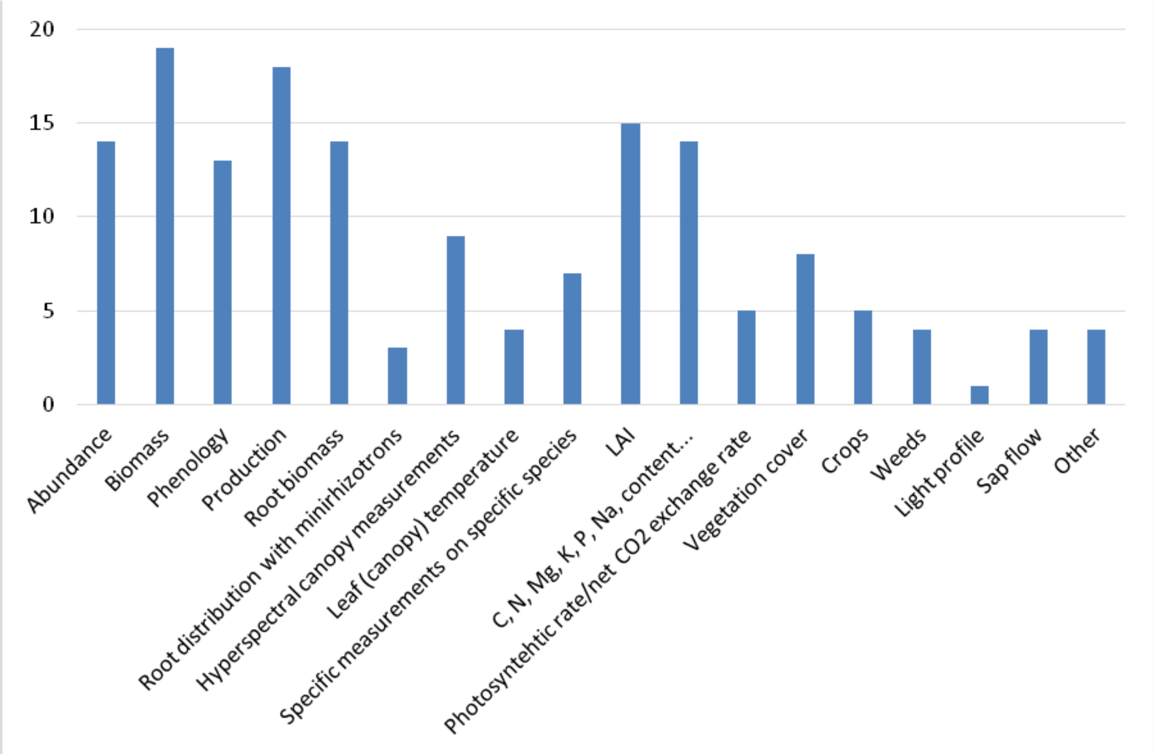


Figure 8. Number of ExpeER sites with different autotrophic compartments

Heterotrophic compartment

Studies of heterotrophs were more limited than autotrophs within the ExpeER sites, with less than half the sites making measurements of biomass and abundance, phenology or other species specific studies (Fig 9). Clearly, there is considerable potential to expand the scope of these studies at most sites.

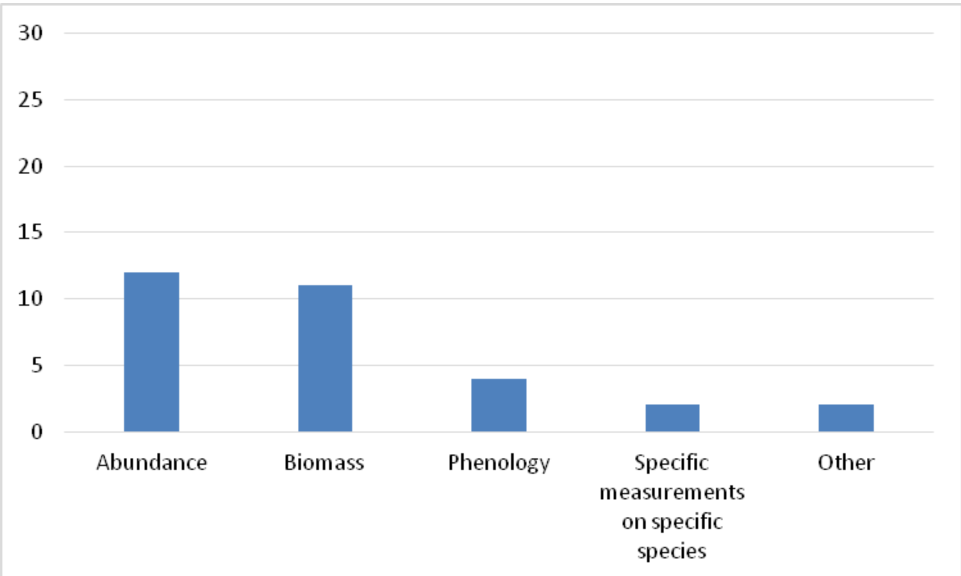


Figure 9. Number of ExpER sites with different heterotrophic compartment measurements

Collaborations and plans for upgrades

Most of the sites are currently involved in significant EU collaborative projects and approximately half are involved in other collaborations (Fig 10). However, only a third are included in other EU databases and feedback indicates that many sites are not generally open for short-term (speculative) collaboration. Most sites have areas where improvements in infrastructure and or equipment/facilities are required and in some cases upgrades are currently being planned.

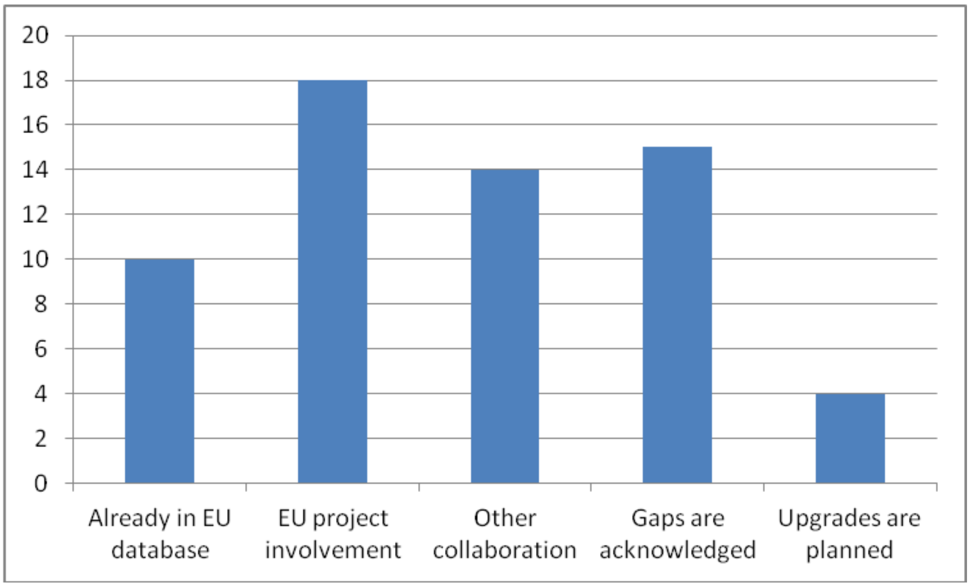


Figure 10. Number of ExpeER sites with other collaborative activities and plans for upgrades.

3.3 Discussion and input from other Work packages

3.3.1 ExpeER site strengths and weaknesses

It was apparent from a detailed examination of the site details that many sites have good technical services and conduct a broad range of meteorological and soil measurements, but many were lacking in laboratory space for collaborative work. There was clear scope to enhance the capacity of most sites with respect to the extent of the experimental manipulations studied in their work and to increase the range of measurements within studies on hydrology, local atmosphere and biodiversity. There was a clear bias in favour of studies on autotrophic organisms (mostly plants) compared with heterotrophic communities.

Two principle approaches could be used to facilitate improvements in the scientific capacities of the sites and enhance future collaborations. Firstly, general improvements could be facilitated by national or European investment in facilities and expertise within all ExpeER sites to enhance the capacities identified above. Alternatively, sites with a similar scientific focus (e.g. biodiversity, hydrology, local atmosphere etc) could be identified as sub-groups within ExpeER to encourage future collaborative work within their areas of expertise. Resources could then be targeted in these areas to increase the capacity and quality of future collaborations. The provision of more laboratory space was identified as a general requirement for most sites. Consequently, this is an important priority to address if ExpeER, is to enhance international scientific collaboration and create synergies that can help achieve its vision of an integrated European research infrastructure.

3.3.2 Synergies and accumulative capacity

To illustrate how multiple sites can provide a more complete set of capacities, we have selected some examples for illustrative purposes. In this case we have shown how combining research facilities in the same geographical region could increase the experimental possibilities, here given for the four ExpeER sites in the UK. The large radial diagram shows the cumulative capacities for the UK sites (Fig. 11) together with the radial diagrams for the individual sites, taken from deliverable D1.1.

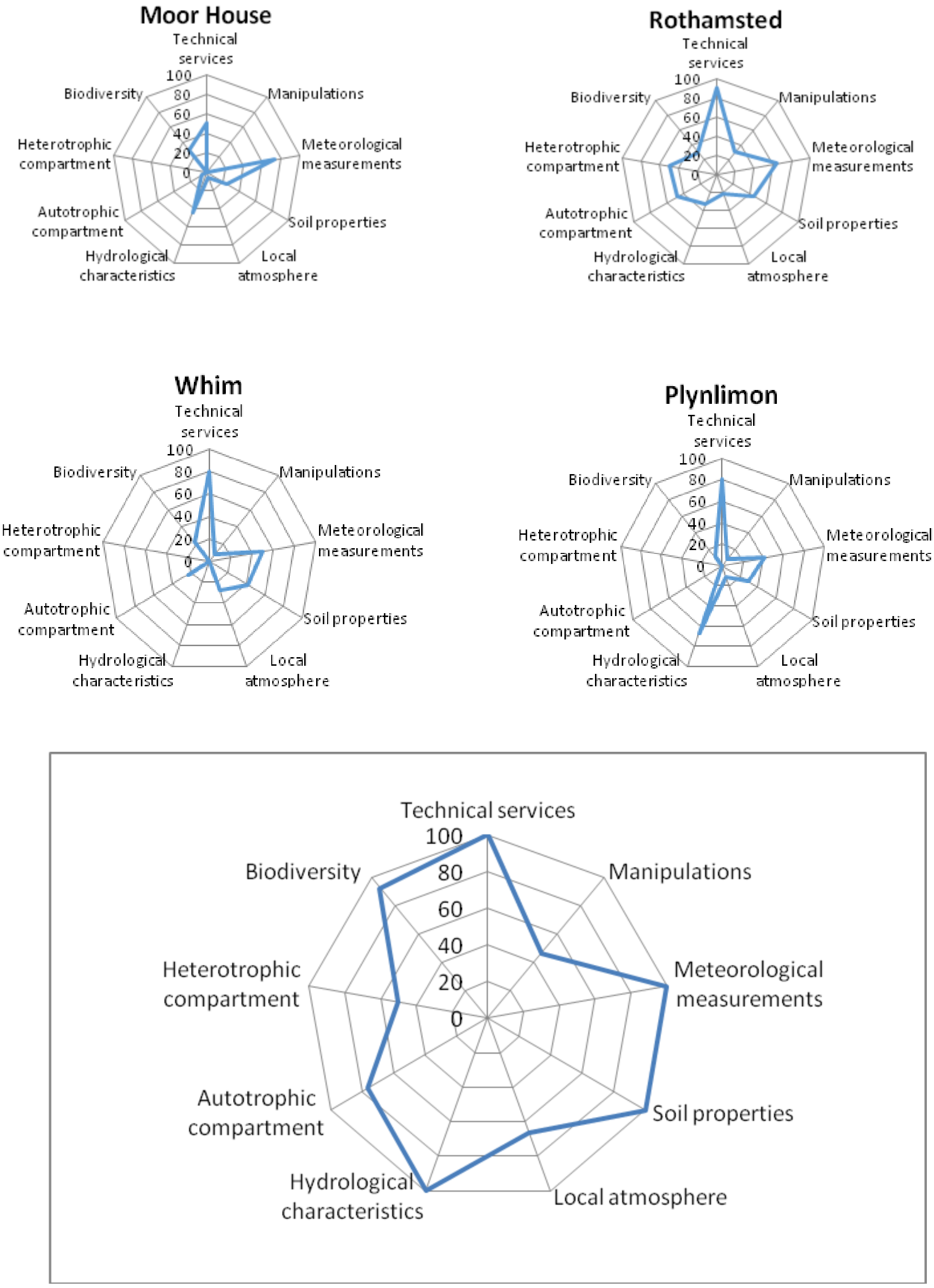


Figure 11. Cumulative research capacities of the 4 UK sites, shown individually above the bottom diagram.

In this example we have simply summarized the capacities for each axis (a maximum of 100 is defined per axis), while in reality one should have made sure that the same capacity is not counted twice. Biodiversity is most likely not overlapping and is giving a real impression of the effect of combining sites and also illustrates the significance of keeping a wide variety of field sites. This kind of analysis done in a more detailed manner might provide the complementarities when using a number of facilities. Many different themes, such as geographical region used in this illustration, could be cselected.

3.3.3 Standardization of core variables and protocols (WP2, Mark Frenzel)

Present data gathering in several fields of ecological research and monitoring is characterized by huge amounts of data related to a high variety of ecological themes. The lack of comparability of these data for joint analysis is hampering the use of these data. Other areas of research such as meteorology have already been through a procedure of standardising measurement techniques, data storage and protocols (e.g. http://library.wmo.int/opac/index.php?lvl=etagere_see&id=39). The primary goal of WP2 in ExpeER was to harmonize measurement and sampling methods for a core set of environmental and ecosystem variables across the focal network of participating research sites, to allow findings to be compared and generalised.

In the USA the ‘National Ecological Observatory Network’ (see Appendix A, NEON, www.neoninc.org) has been set up to enable a better understanding of continental-scale ecology. NEON is a project solely funded by the National Science Foundation. The funding is the prerequisite for implementing harmonized measurements within the network. NEON is designed to gather and synthesize data on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. Data will be collected from 106 sites (60 terrestrial, 36 aquatic and 10 aquatic experimental) across the U.S. (including Alaska, Hawaii and Puerto Rico) using instrument measurements and field sampling. The sites have been strategically selected to represent different regions of vegetation, landforms, climate, and ecosystem performance. NEON will combine site-based data with remotely sensed data and existing continental-scale data sets (e.g. satellite data) to provide a range of data products that can be used to describe changes in the ecosystems through space and time. NEON is expected to be in full operation by approximately 2017. The National Science foundation has also funded the US-LTER (Long-Term Ecological Research) site network since 1980 (http://www.lternet.edu/).

In order to tackle global grand challenges, NEON-like networks would be needed on other continents too. These networks should be connected using advanced cyber-infrastructures and global remote sensing programmes. The ExpeER project is integrating four types of ecological research infrastructures within the fragmented European research landscape, but creating a European NEON-like system would require funding and coordination of a different order of magnitude.

One of the main challenges of standardising parameters in WP2 of the EXPEER project was to identify appropriate indicators describing the main features of ecosystems. To tackle this issue, a survey among EXPEER partners on the parameters they are measuring was performed and results were used as one of the inputs to create an extensive set of indicators targeting key elements of ecosystems. In order to justify the selection of indicators by applying a conceptual framework describing ecosystems, indicators were arranged according to the “Ecological Integrity” framework, which focuses on the ability to sustainable self-organisation of ecosystems (Müller et al., 2000). The main components of this framework (ecosystem structures and processes) are targeting at the pressures on, and state of, ecosystems. Ecosystem structures are well characterized by biotic diversity (flora and fauna) and abiotic heterogeneity (soils, sediments, water, air) forming habitats. Ecosystem processes (cycling of energy, matter and water) are characterized by indicators of inputs, storages and outputs. The general requirements (and challenges) for parameters targeting at indicators are that they are easily measurable, indicative, clear, sensitive and provide a high utility for early warning purposes. In order to join forces and create added value, the standardisation efforts in Expeer built on and extended the work of the EU funded LIFE+ project; EnvEurope (http://www.enveurope.eu/). The complete list of parameters and the related methods can be queried in the interactive web tool ECOPAR (http://www.ufz.de/lter-d/index.php?en=32141&contentonly=1). Compared to the centrally funded US NEON there is no similar program in Europe facilitating harmonized measurements within and across countries. Thus we can only provide recommendations and databases about why, what and how to measure.

The second step was to provide agreed protocols for a set of key parameters, in order to serve as test cases for transboundary analyses. Our goal was to choose a list that could serve as a pilot for establishing a set of parameters with standardized protocols. The parameters were chosen according to the following criteria: they must (1) be considered important to ecosystem integrity, (2) common to many ecosystem research sites, (3) allow protocols of an intermediate complication level, (4) provide easily executed and not too expensive protocols and (5) parameters should cover a variety of areas within terrestrial ecosystems.

A short list of 10 parameters was selected by the EXPEER WP 2 group: Land Use and Management, Soil Microfauna Diversity, Decomposition, Organic Matter – Carbon and Nitrogen Stocks, Trace Gas Emissions, Leaf Area Index, Transpiration measurements in woody and herbaceous plants, Biomass; Biomass and Leaf Area Index in grassland and arable land.

Courses were held in the Netherlands and Italy applying the following protocols:

1. Leaf Area Index (Forest, grassland)
2. Plant biomass (Forest, grassland)
3. Soil macrofauna (QBS technique, bait lamina, litterbags)
4. Soil organic matter (sampling and analysis)
5. Soil respiration (different techniques)
6. Evapotranspiration (sap flow, eddy covariance)
7. Land Use Type (landscape analysis)
8. Soil moisture (discussion only)
9. Plant phenology (discussion only)

Later Evapotranspiration was replaced by

10. Metadata for sampling, experiments and data management

Most attendants of these courses were PhD students and not site managers. Though the PhD students in their future work may request a harmonization of protocols, the lack of site manager representation at these courses may delay the harmonization process across the sites. Hence incentives are needed in future to ensure site managers and personnel acquire up to date knowledge of the newest technology and standardization procedures. Incentives could be economical or set by national mechanisms in other ways.

3.3.4 Information management and data access (WP3)

According to the website of the International Ecological Information Management System (DEIMS) http://data.lter-europe.net/deims-dev/the site provides a web client interface for several networks and projects including International Long Term Ecosystem Research (ILTER) network:

- LTER - Europe network
- EnvEurope project
- ExpeER (Experimentation in Ecosystem Research) project

The stakeholders can describe, discover, view and download information about: Data sets, Research/observation sites, Bibliographic references, Personnel information including research topics and expertise. The tool is based on the First release of Drupal metadata editor provided by colleagues from the US LTER network and related ongoing development of Drupal Ecological Information Management System.

A compatibility test was conducted between the DEIMS questionnaire and the WP1 questionnaire. The test was performed by a WP1 partner who did not have explicit knowledge about the EXPEER sites, but rather tried to fill in required information in the DEIMS, based on eth already collected data in WP1 (D1.1). The conclusion was that the two questionnaires serve a different purpose: The ExpeER questionnaire is very detailed in terms of the type of measurements that can be conducted on a site, while the DEIMS questionnaire focuses on site properties/characteristics and infrastructure. In the case of Apelsvoll (which was used as an example EXPEER site), many fields in the DEIMS questionnaire could not be filled in. Of course whether data could easily be filled into the DEIMS system also depends on the way the ExpeER questionnaire has been filled out by the site managers. In some cases more detailed information is given in the comment fields, but this requires that the person filling the info into the DEIMS sheet searches the ExpeER questionnaire for details, which will be quite time consuming. The ExpeER questionnaire would need many additional fields in order to provide the correct information for the DEIMS database. There are several fields in the DEIMS questionnaire such as "General description", "Purpose", and "History" that require more detailed text, which can easily be filled in by the site manager directly. However, this info is not available from the ExpeER sheet.

Based on this analysis it was concluded that it would be more efficient to ask site managers to fill in site specific information into the DEIMS database themselves. This will not only save time, but the information requested will also be more complete and detailed than what can be extracted from the ExpeER questionnaires. Incentives are needed to motivate all site managers to fill in the required information about their site. An example could be that national funding will only be provided if sites have completed their registration, or there are other national or international mechanisms in place. In the case of LTER-Europe sites are only formally acknowledged, when a set of 50 parameters is completely filled.

3.3.5 Creating a sustainable network (WP4, Michael Mirtl)

Motivation for WP4 on networking and main lines of actions: Many infrastructures for ecosystem research target at producing information about system behaviour beyond the time span of individual research projects. Sites and their equipment should be multiply used to increase efficiency (experiments). Long-term observations provide valuable information on trends in response to main drivers. Therefore, ExpeER was challenged to anchor the infrastructural elements comprised by the ExpeER pyramid in the landscape of related projects and infrastructures. Besides from developing a smart division of tasks with these projects and infrastructures, options for the permanent operation and funding of ExpeER´s elements needed to be explored. Recognizing the fact, that ExpeER was limited to sites owned by consortium members, but not based on a quantitative overview of European facilities, efforts were made to attract comparable sites, their Primary Investigators and institutions to ExpeER, its concepts and products. To this end a Related Sites Group was established.

Getting an overview of the strategic environment of ExpeER: A comprehensive inquiry of relevant networks, projects, infrastructures, strategic processes and funding mechanisms was carried out based on input from the ExpeER community, stock takes in the WEB and bilateral interviews with relevant co-ordinators and stakeholders. The elements of the resulting database were prioritized, grouped into main branches such as “In-situ observational research networks” and “In-situ experimantal research networks” and graphically illustrated in a MindMap of the strategic environment of ExpeER.

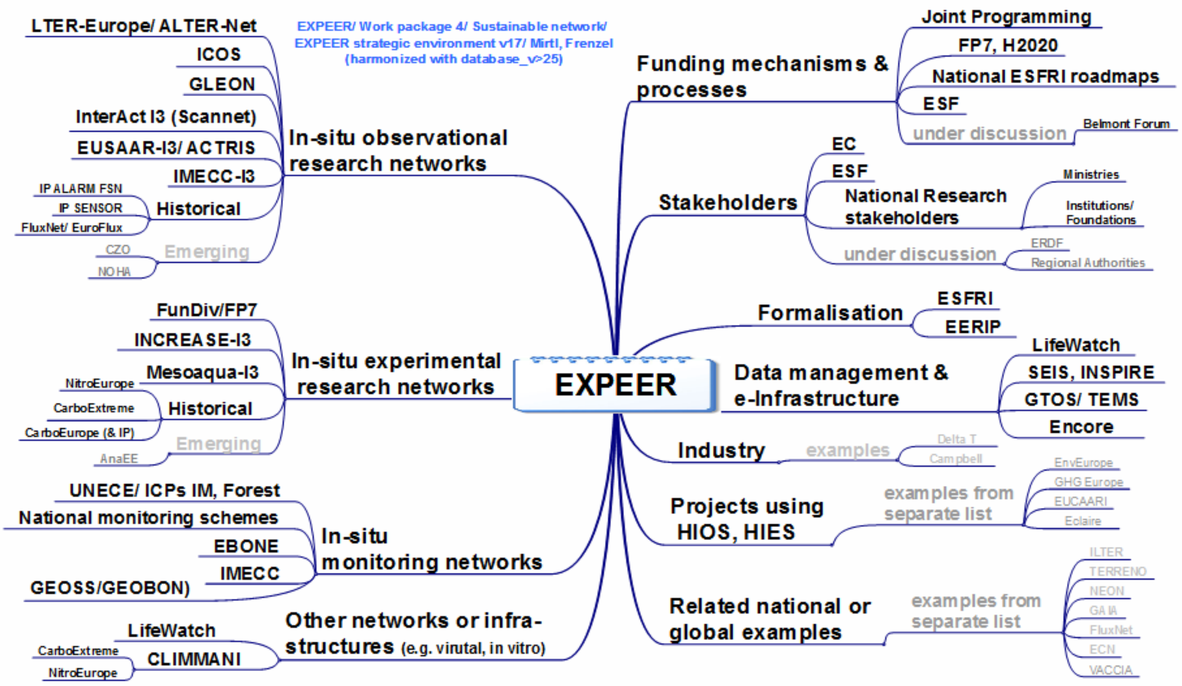


Figure 12. Mindmap to illustrate links between different nextworks (M. Mirtl, WP4)

The left side of the MindMap represents related research infrastructures, whereas the right side covers the strategic environment, services and users.

The Related Sites Group (RSG) is an outreach- and feedback-body consisting of Primary Investigators (PIs) of Highly Instrumented Sites, which are not working with one of the ExpeER partner institutions. It offers an opportunity to informally affiliate with ExpeER. The RSG provided valuable input to the conceptual and strategic work of ExpeER, including criteria for highly instrumented sites.

Networking towards sustainable infrastructures: The MindMap of ExpeERs strategic environment gives evidence, that ExpeER could build on several initiatives (e.g. ICOS, AnaEE), networks (e.g. LTER) and projects (e.g. EnvEurope). It also shows, that ExpeER represents a novel combination of peers from the experimental and observational research community and provided a platform for identifying their common ground, specifically in the field of IT tools, standards and methods. Joint experts groups across projects were fostered and ExpeER introduced at most key events of relevant networks and projects since 2010, including the biodiversity research community and monitoring networks (nationally, in Europe and globally).

Permanent funding

The ExpeER pyramid represents the conceptual elements of the project, comprising Ecotrons, Highly Instrumented Experimental, Highly Instrumented Observational research sites, modelling and analytical platforms. The hierarchical design of ExpeER also envisages strategic interactions between these actual research infrastructures and larger scale monitoring schemes.

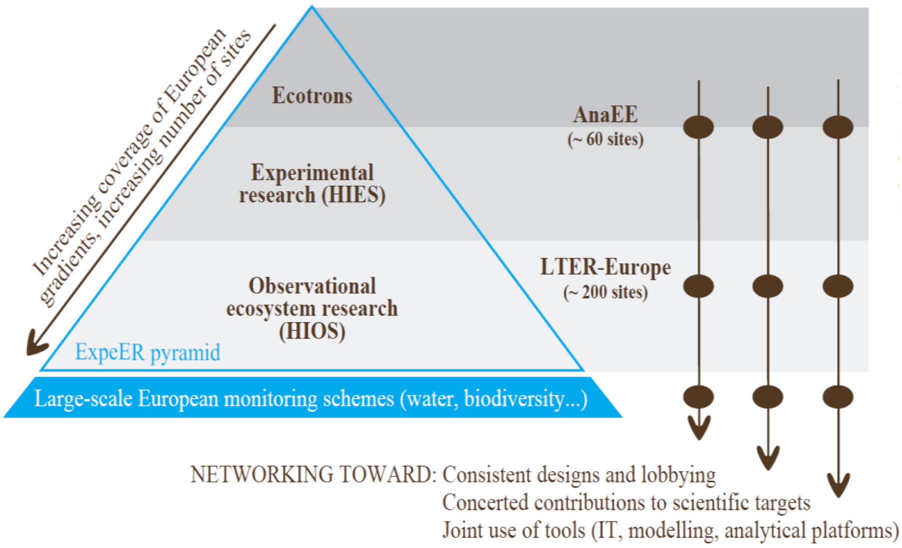


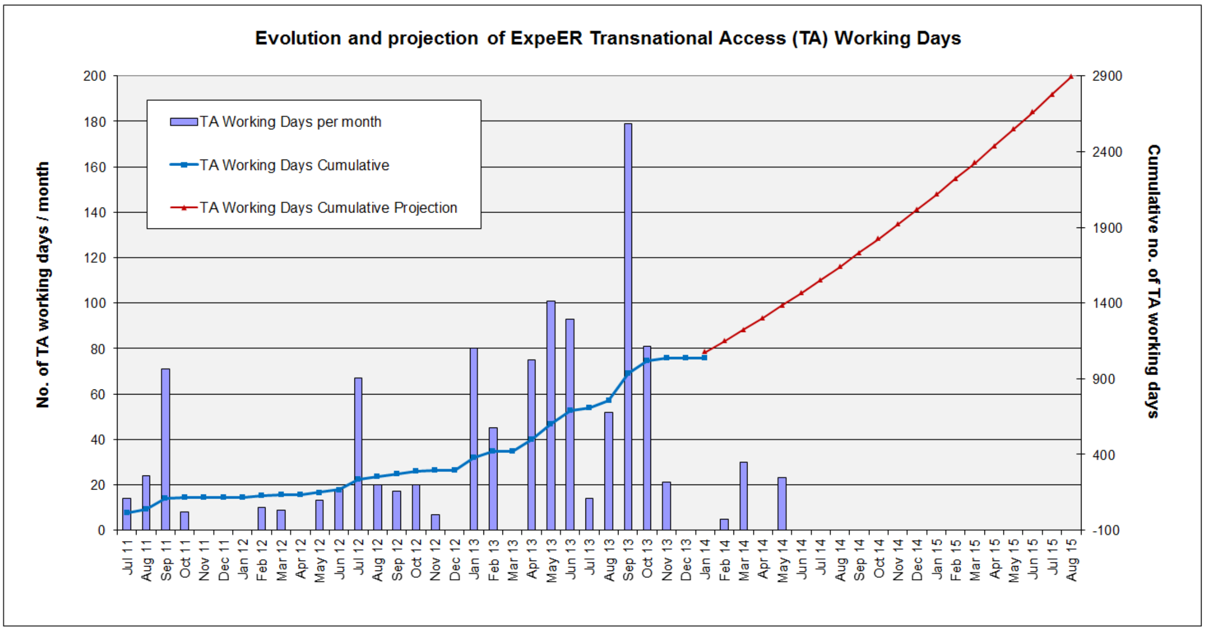
Figure 13. ExpeER pyramid. ExpeER paves the way for the European integration of various complementary ecosystem science infrastructures.

Fostered by ExpEER, there are good chances for the successful implementation of its building blocks (AnaEE, LTER-Europe) in a highly co-ordinated manner and as part of a European environmental research infrastructures cluster. This will support highly integrated national ecosystem research infrastructure clusters, their efficient multiple use towards scientific targets and the joint development of further services. The AnaEE project was successful and entered its preparatory phase (2012 –2016). LTER-Europe is based on solid governance structures and national networks in 21 countries and prepares a H2020 I3 project.

ExpeER and the outside world – towards a division of tasks in the European Research Area: Intense discussions are ongoing with ICOS, LifeWatch, InterAct and other networks about the further structuring and design of the European infrastructures in the field of biodiversity and ecosystem research in preparation of the next ESFRI roadmap. The role of ExpeER in the interplay of observation, experimentation, the generation of large scale reference data and modeling need to be continued.

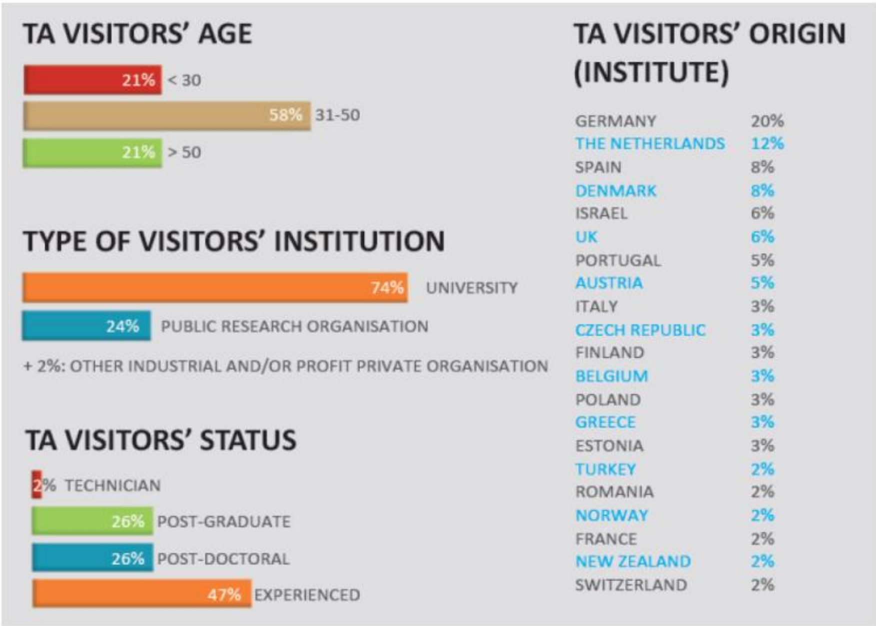
3.3.6 Transnational access activities (WP6, Cristina Martinez)

Based on the ExpeER TA experience (WP6) there has been a lack of scientific community interest to use the sites/facilities. By October 2013, 45 visits had been completed. The most popular sites were Negev (Israel), Whim (UK) and Fruska Gora (Serbia), while 6 sites had not received any TA applications, the number of Transnational Access visits has however increased since the beginning of the project (Fig. 14) indicating that the lack of visits might be a start-up problem. The good news is that 97% of the users are satisfied. The most important mediator of site visits was personal contact. Hence other efforts for communicating these possibilities should be revised and included in the EXPEER roadmap. An analysis of who uses the TA sites shows that the largest numbers come from Germany and the Netherlands, otherwise there is a good distribution among the European countries (Fig.15). It also shows that experienced scientists form the largest group, which perhaps is somewhat surprising. Understanding why scientists are reluctant to apply for mobility grants should be explored further, a number of factors could be present; economic (not enough resources with respect to time efforts of proposal work), lack of information, not sufficiently marketed etc. The next step is to improve these.



* Data updated on 13 February 2014. Figures of TA days in 2014 come from TA projects that are validated but not started yet.

Figure 14. Number of TA applications (Cristina Martinez, Yuchong Tang, WP6)



*** statistics at October 2013

Figure 15. Who has visited the ExpeER sites? (Cristina Martinez, WP6)

3.3.7 **Technological development** (WP7, WP8, WP9 and WP10)

Specific technological developments such as the potential of cosmic ray probes for the assessment of soil moisture at the field scale (D7.1) and improvements in terms of sample preparation for applying nanoSIMS (secondary ion mass spectrometry) approaches to the study of soil aggregation by specific organic matter components (D7.2) have been explored in WP7. Further, for experiments simulating future elevated temperatures, the use of Computational Fluid Dynamics (CFD) to design CO_2 enrichment, new designs of new approaches for experimental ecosystems and the new generation of biodiversity/climate change experiments were addressed by WP8. These have been reported in Deliverable 8.1, which reports on weaknesses and limitations in current techniques/approaches to study ecosystems in future. The question is how do ExpeER or other similar distributed infrastructures ensure that new developments are implemented in their existing facilities? The work with upscaling in WP10 revealed that there were uncertainties of measured *Net Ecosystem Exchange* (multiple EC towers). The Community land model (CLM) includes: Water, Nitrogen and Carbon. The ExpeER site, Eifel, Germany: http://www.expeeronline.eu/index.php/list-of-sites/descriptions/128 was used to test the upscaling approach. The challenge is that the energy balance is not closed with the available data. The Global land surface model, ORCHIDEE (Organising Carbon and Hydrology In Dynamic Ecosystems), developed by Institut Pierre Simon Laplace (IPSL) earth system model, was tested in WP10. Less than 60 sites (including NEE and LE fluxes) are used to optimize 50 parameters in the Orchidee model, revealing a strong need for more sites and the importance of ExpeER data/sites for quality checking of global climate models (GCM). Challenges in validating the model was caused by missing temporal water saturation data. Mechanisms to increase the ExpeER facility capacity over time should be developed.

4. Roadmap/Recommendations

A roadmap for the European ecosystem research infra structures is a plan that matches short-term and long-term goals with specific research need solutions to help meet those goals. In this report, a number of needs are identified and priority areas for investment are suggested (capacity areas). Development of a roadmap has three major goals. It helps reach a consensus about a set of needs and the type of facilities required to satisfy those needs; it provides a mechanism to help forecast developments within ecosystem research facilities and it provides a framework to help plan and coordinate future developments, both organizational and technological.

Major scientific questions still left unanswered within ecosystem research, possibly without adequate facilities to study such processes, include how will biodiversity develop as a function of climate and landuse change? What are consequences of climate change on ecosystems and functioning? Large scope for multiple treatment designs. Do we have sufficient knowledge for optimizing and designing ecological engineering? How can phosphorous limitation affect productivity of natural and agroecosystems in the future? These questions should typically be possible to study by combining experimental work at the experimental ExpeER facilities (HIES), more detailed process studies at analytical platforms, modeling processes at different scales and validation with long term observations (HIOS). Highlighting these issues however does not by itself drive a process where the European ecosystem research community can easily join forces in order to obtain the right tools for the right questions at a pan-European level. What are the incentives that could drive such a process?

An important question concerning the ExpeER road map is “Where do we want the roadmap to take us?” To answer this question we need to define who the users of such a road map are. The following groups and their objectives can be suggested:

Table 1. User groups for the ExpeER facility and their goal/motivation for participation

User group	**Goal**
Research scientists e.g. ecologist, hydrologist, biologist, climate modellers, soil scientist	***Access*** to experimental facilities that can provide ***the advanced technology*** and ***data*** needed for model calibration and validation. Sufficient ***coverage of ecosystem/climate zones.***
Site managers	***Sufficient use*** of facility and participation in research projects, ensure *complementary* facilities across Europe. Consistent and ***comparable measurement schemes. Technological development*****.**
Policy makers and governments	Ensure ecosystem research contributes to economic development, innovation, social wellbeing, environmental sustainability and Europe's prosperity. Make sure Europe's funds are well spent, ***efficient use of facilities***, ensure ***complementarities and synergy effects*****.**

In the next sections a few of the highlighted goals in Table 1 are discussed further in the context of the information provided by the ExpeER facilities. The gaps and future needs are based on the results of the questionnaires using the scores along the different axis of the radial diagrams; Technical services, Manipulations, Meterological measurements, Soil properties, Local atmosphere, Autotrophic compartment, Heterotropic compartment, Biodiversity (Fig. 11). Elements required to complete a roadmap successfully are outlined in Figure 16. The figure illustrates the incentives as well as technological and managerial components required to make a pan-European distributed infrastructure successful. The economic incentives can include funding mechanisms provided by the EU, nationally, governmental or commercial interest.

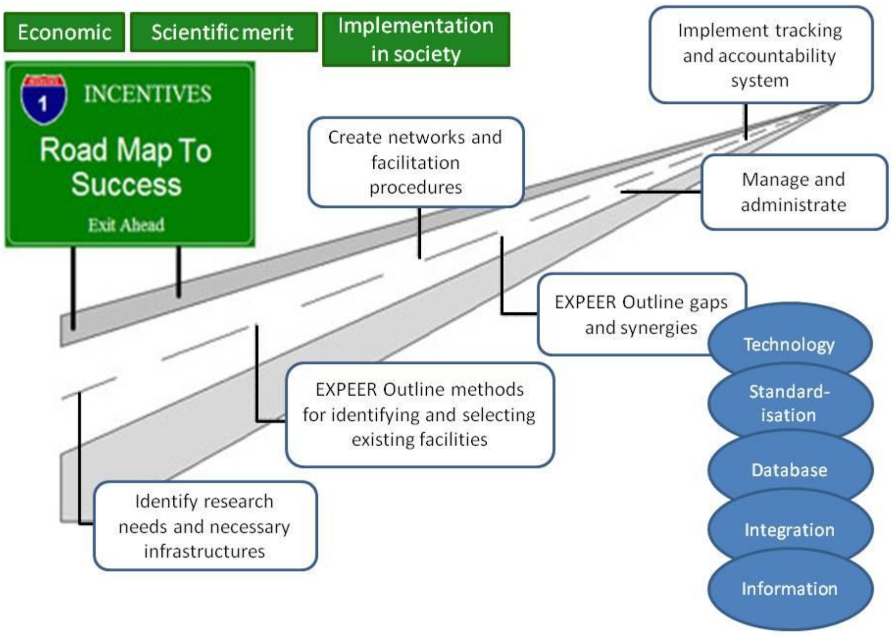


Figure 16. Necessary steps towards the successful implementation of a pan-European infrastructure for ecosystem research. Contributions by the ExpeER project in blue and incentives necessary in green.

5. Access to research facilities and data

Based on the ExpeER experience seen in WP6 (3.3.6), there seems to be a lack of tradition to seek alternative facilities and experimental field sites for conducting ecosystem research, or the funding that has been available is simply not attractive enough for there to be a large competition for transnational access funds provided through the ExpeER project. Several of the sites are not associated with any modeling platform, which may illustrate that the main problem for multiple use of collected data at the distributed ExpeER infrastructure might not be access to data, but rather lack of data required for specific models. Modeling is an important step for knowledge transfer between locations and scales. The hydrological response functions (e.g. discharge, drainage, groundwater level) are highly under represented; there is a great need to ensure that hydrological response data are collected in order to ensure transferability of knowledge across European ecosystem research facilities. Any distributed facility that is accepted for a Pan-European research facility should show that their data has been used for modeling.

5.1 Ecosystem and climate zone coverage

Clearly the ExpeER sites do not provide a complete coverage of ecosystem and climate zones, for instance forest ecosystems are highly over represented compared to the landuse distribution in Europe (D1.1). Less common were manipulations of atmospheric variables, biodiversity, temperature and drainage; no manipulations of ozone, salinity or radiation (light) were evident. This preliminary analysis indicates that there is scope to increase the number of manipulative experiments across the ExpeER network, even for the most commonly studied treatments (landuse, irrigation, soil management etc). For climate change research these variables are highly relevant and can truly help validate estimates of earth responses and feed-back mechanisms as a function of climate change. The present analysis reveals a great need to increase this capacity at the examined facilities, and for close collaboration with other infrastructure projects such as ICOS. There is a need to expand the biodiversity studies at the ExpeER sites to include more work on macroalgae, mycorrhiza, annelida, crustaceans, athropods and food webs. The capacity for studying biodiversity as well as the autotrophic and heterotrophic compartments should be increased. More collaboration between facilities and number of experts on each facility is strongly recommended to make the distributed ExpeER more robust. Issues that are not covered in the capacity of the in-vitro facilities include frost and snow, manipulations and biodiversity, and the need for better ways of quantifying population changes and population biology (dynamics and real time observations).

5.2 Scientific mobility/sufficient use of facilities

As described in section 3.3.6 there is a lack of scientific community interest to use the sites/facilities. Three of the WPs play an important role in getting more researchers to do their experiment at a the distributed ExpEER infrastructure: WP4 dealing with the extended networks, WP5 leading the information work both through the website and by producing flyers and posters which can be presented at relevant meetings and WP6 managing the Transnational Access. Designing formal admistrative tools is possible – but how do scientists working will these tools increase interest for transnational access? Sites should be oriented to future questions and society needs. Some of the key factors to be included in a framework for future collaboration are:

- Exploration of new funding opportunities (e.g. ESFRI, Horizon2020). The large number of participates of ExpeER is an ideal basis for a Horizon2020 proposals, e.g. calls in the Focus area "PROTECTING THE ENVIRONMENT, SUSTAINABLY MANAGING NATURAL RESOURCES, WATER, BIODIVERSITY AND ECOSYSTEMS"
- Further maintenance of the ExpeER website. To make the website more attractive it should be further enhanced. For instance online webinars could be provided on regular basis, in which ExpeER partners would be invited to give lectures.
- Young academics training programs could be initialized (e.g. PhD exchange programs, summer schools, further training seminars)
- Workshops organised in collaboration with funding mechanisms (EU, others)
- ANAEE and similar can/should be mentioned in the calls (lobbying)

5.3 Consistent and comparable measurement schemes

Further work that could be done in order to ensure more consistent and comparable measurements:

- Comparing artificial conditions to field measurements
- Synchronise types of measurements possible at ecotrons and at field sites
- Electronically connected field sites to ecotrons, e.g. through common database system
- Put in place a system for monitoring of performance
- Standardisation of European/international standards for certain measurements
- Establishment of European accreditation offices

5.4 Technological development

According to replies to the questionnaires, few ExpeER sites have plans for upgrade of the site, in view of the many gaps highlighted above this reveals a clear weakness of the ExpeER infrastructures. Whether there really are no plans for upgrades or it just hasn't been filled in or whether no plans exists because of lack of funding is not clear, but it is evident that for Europe to maintain a leading role in international ecosystem research, future capacities and technological developments should be well supported. A further analysis of why upgrades are not planned should be conducted. A set of mechanisms to increase capacity over time should be developed.

5.5 Efficient use of facilities, ensure complementarities and synergy effects

While most of the ExpeER sites are involved in collaborative project through EU and national funds, the funding security of the sites is one the main vulnerabilities of several of the sites. The question is how to ensure that Europe has the optimal number of facilities and that these are funded in future? Ensuring European wide optimisation process of a distributed infrastructure, while individual nations are responsible for their own site is challenging. Major efforts should be put in place to encourage collaborative European research projects e.g. EU funded initiatives to make use of an EU distributed infrastructure. This must be highlighted in future funding and collaboration mechanisms such as ANAEE, Horizon 2020, LTER, COST actions. Modelling is required for integration of experimental platforms in both time and space, and is another necessary step for ensuring efficient use of facilities in the future.

In addition to modelling efforts, integration of analytical platforms and ecotrons with field sites can be obtained by

- Make the ExpeER database (DEIMS) described in section 3.3.4 more available and easily accessible and make improvements in data sharing capacity or options. Alternatively, or in addition, use GeoNetwork software (http://geonetwork-opensource.org/) to set up a prototype metadata portal to share common metadata information, e.g. on field observation data of the ExpeER sites. This would enable users of the portal (internal as well as external researchers) to search for data sets, e.g. for regional analysis.
- Explore the possibilities to set up a European system comparable to NEON as part of ESFRI and other European coordinated activities for future research funding.
- Global scale coordination should also be enhanced as part of e.g. GEOSS (www.earthobservations.org/geoss.shtml).
- Coordination of national and European level support for ecological research infrastructures is improved to allow more efficient use of resources and establishment of larger, better funded and coordinated infrastructures (cf. NEON).

5.6 Selection criteria for future facilities

The work of WP1 in EXPEER has outlined a method for comparing existing facilities, finding gaps and scopes for investments in the future. Based on the contents of this report the roadmap displayed in Table 2 can be suggested for the different groups of ExpeER facilities.

Table 2 A road map for the ExpeER facility, short and long term milestones for the facility categories

ExpeER facility	Short term	Long term
HIES	Increase visits, plans for technological upgrades	Become part of ANAEE
HIOS	Increase visits Database, technological upgrades, standardisation	Are part of LTER
Analytical platforms		Become part of ANAEE
In-vitro platforms		Become part of ANAEE
Modelling platform		Become part of ANAEE, co-operate with LTER

We have not tried to rank the facilities in this work package as the objective was mainly to give an overview of capacities, outline gaps and possible synergies. For a future coordinated ecosystem research platform including in-vitro (ecotron) facilities, experimental and observational facilities, analytical and modeling platforms it is reasonable to expect that certain minimum criteria (which data, data quality, modeling suitability) are defined in order to ensure national contributions to such a coordinated research facility are met. The roadmap outlines actions both within the time frame of, but also after the ExpeER project has ended. The longer-term objective of ExpeER is to increase the Euopean and international ability to tackle climate change and ensure sustainable land use.

In order to rank facilities or evaluate progress of existing facilities measurement of the performance of the facilities is required. Quality of performance can be assessed through different measurements for example number of publications, number of visits, annual investments, etc. depending on the user groups and goals suggested in Table 1. An illustration of how this could be presented is given in Figure 17. The figure also includes how thresholds for technological and performance criteria could help select sites to be included in Advanced scientific infrastructures.

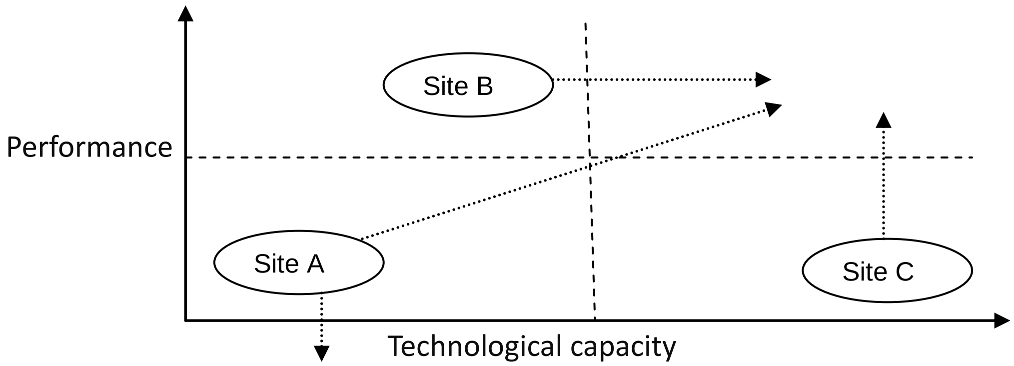


Figure 17. Presentation of facility performance and guide for development

The arrows indicate in which direction sites should aim to develop in future. If the performance criteria was publication, it would for instance be expected that a newly established facility has a low score (e.g. site C), hence their aim should be to publish more. While Site B has performed well, but is lagging behind technologically and hence should consider upgrading of instrumentation etc. Site A has to improve performance and upgrade, if the ecosystems/geographic region/etc. that it represented is also found elsewhere, it might be relevant to give this facility less priority and possibly close it down in favour of upgrading others.

AnaEE (Infrastructure for Analysis and Experimentation on Ecosystems) is part of the European Strategy Forum on Research Infrastructures Roadmap (2010) as a new distributed EU infrastructure for ecosystem research. The vision of ANAEE (http://www.anaee.com/index.php/) is that it should be 'a research infrastructure for experimental manipulation of managed and unmanaged terrestrial and aquatic ecosystems. It will strongly support scientists in their analysis, assessment and forecasting of the impact of climate and other global changes on the services that ecosystems provide to society. AnaEE will support European scientists and policymakers to develop solutions to the challenges of food security and environmental sustainability, with the aim of stimulating the growth of a vibrant bioeconomy. AnaEE will accomplish this mission by building permanent and substantial links among researchers, science managers, policy makers, public and private sector innovators, and citizens.'

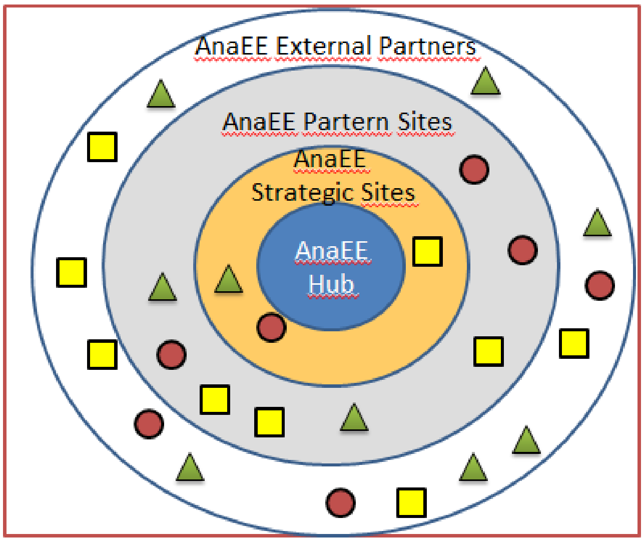
1. In the process of defining the Layout of AnaEE, a central coordination is facing a challenge made of two conflicting objectves.

2. On one hand AnaEE should aim at preserving the wide community of ecological research institites with their experimental sites. In fact they embodies great value in terms of cumulated scientific experience, collected datasets and technological knowledge on specific subjects (such as sensors or models to be used in a particular ecosystem).

3. On the other hand AnaEE should aim at identifying a network of Excellence to which National and European funds should be allocated to provide important upgrades.

4. This problem could be solved by identifying a multiple layer participation scheme. A central guidelines could be provided in terms of requirement for sites to be upgraded.
    a. Such technological guidelines should be coherent with a central research strategy, where research priorities are identified (i.e. which Ecosystem x Climate x Pressure are the most important).

b. In this perspective an evaluation for identifying target sites for major upgrades should be undertaken either by a Central European decision maker or by national decision maker coherently with the identified Research Strategy for AnaEE.



5. Both prioritization of EcosystemsXPressures in the Research Strategy and identification of upgradable sites involve conflicting objectives.

A method for selecting facilities suggested in the ANAEE project is the Multi Criteria Decision Analysis (MCDA). This method explicitly considers multiple criteria in decision-making. According to http://www.ncsu.edu/nrli/decision-making/MCDA.php, "Multi-Criteria Decision Analysis, or MCDA, is a valuable tool that we can apply to many complex decisions. It is most applicable to solving problems that are characterized as a choice among alternatives. It has all the characteristics of a useful decision support tool: It helps us focus on what is important, is logical and consistent, and is easy to use. At its core MCDA is useful for:

- Dividing the decision into smaller, more understandable parts
- Analyzing each part
- Integrating the parts to produce a meaningful solution

When used for group decision making, MCDA helps groups talk about their decision opportunity (the problem to be solved) in a way that allows them to consider the values that each views as important. It also provides a unique ability for people to consider and talk about complex trade-offs among alternatives. In effect, It helps people think, re-think, query, adjust, decide, rethink some more, test, adjust, and finally decide.

MCDA problems are comprised of five components:

1. Goal
2. Decision maker or group of decision makers with opinions (preferences)
3. Decision alternatives
4. Evaluation criteria (interests)
5. Outcomes or consequences associated with alternative/interest combination"

There are typically multiple conflicting criteria that need to be evaluated in making decisions. In the ExpeER case it could be technological level or quality on the one hand and cost or price on the other hand. Many systems engineering decisions are difficult because they include numerous stakeholders, multiple competing objectives, substantial uncertainty, and significant consequences (della Porta and Fracaro, 2014) In these cases, good decision making requires a formal decision management process. An example: how MCDA Facilitates Issuing and Managing the “Call for Application” of experimental sites

The MCDA involves the steps defined in ‘Multi criteria analysis: A manual: UK Department for Communities and Local Government, 2009’:

Designing and planning	
Step 1.	Establish the aims of the MCDA
Step 2.	Identify decision makers, stakeholders, and persons with relevant expertise
Step 3.	Design the MCDA intervention
Collecting data	
Step 4.	Identify the options
Step 5.	Identify the criteria
Step 6.	Score the options on the criteria
Step 7.	Weight the criteria
Analyzing data	
Step 8.	Compute overall ranking
Step 9.	Conduct sensitivity analysis
Reporting findings	
Step 10.	Write up Modelling exercise
Step 11.	Integrate MCDA findings with other ad hoc methodlogies adopted
Step 12.	Include a summary of adopted methods in Appendix

The method has been illustrated based on results from ExpeER WP1, Deliverable D1.1 (della Porta and Fracaro, 2014). It is emphasized that the example attached as Appendix B (della Porta and Fracaro, 2014) is only meant as an illustration of how such an analysis could be performed in order to make a decision based on the collected material from the questionnaires. The example illustrates the quest of which forest sites should be selected for further upgrade, independent of costs considerations issues. Four out of the full range of selection criteria are selected, in this example: Experimental size, Technological capacity, accessibility and analytical capacity. The end point is an overall ranking of the four tested sites, ranking them from 1-4 (Appendix B).

6. Conclusive remarks

Two principle approaches could be used to facilitate improvements in the scientific (technological and modelling) capacities of the sites and enhance future collaborations. Firstly, general improvements could be facilitated by national or European investment in facilities and expertise within all ExpeER sites to enhance their scientific capacities. Alternatively, sub-groups with similar areas of expertise (e.g. biodiversity, hydrology, local atmosphere etc) within ExpeER could develop future collaborative work within these areas. Resources could then be targeted to increase the capacity and quality of future collaborations in these areas. Although technical facilities at most of the ExpeER sites are good, there is a need for more laboratory space at many sites (Fig 1).

Consequently, this is an important priority for ExpeER to address to enhance international scientific collaboration and create synergies that can help achieve its vision of an integrated European research infrastructure.

- Ecotrons should provide a facility at such an advanced level, but they cannot exist in every country. The total capacity however might require similar features of some of these ecotrons. New and existing ecotrons should be complimentary.

Administrative challenges that need to be addressed concern putting in place

- Systems for effective sharing of data to ensure availability, this implies safe systems for data storage (metadatabase), consistency of data including data format, and incentives for making sure new data are included in sharing systems.
- Incentives for continuous technological upgrade of selected facilities
- Coordinated funding mechanisms between EU and individual nations
- Funding and administrative mechanisms which promote international collaboration at the distributed research infrastructure.

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Appendix A Other relevant networks (direct quotes from webpages)

ANAEE (http://www.anaee.com/, 22.05.2014)

VISION: Analysis and Experimentation on Ecosystems (AnaEE) will be a research infrastructure for experimental manipulation of managed and unmanaged terrestrial and aquatic ecosystems. It will strongly support scientists in their analysis, assessment and forecasting of the impact of climate and other global changes on the services that ecosystems provide to society.

AnaEE will support European scientists and policymakers to develop solutions to the challenges of food security and environmental sustainability, with the aim of stimulating the growth of a vibrant bioeconomy. AnaEE will accomplish this mission by building permanent and substantial links among researchers, science managers, policy makers, public and private sector innovators, and citizens.

FUNDING: The European Commission's 7th Framework programme (DG Research & Innovation) is co-funding the Preparatory Phase of AnaEE (Grant Agreement n°312690) that will run for a period of 3 ½ years from 1st November 2012 to 30th April 2016. In addition to national funding provided by France, Belgium, Italy, UK and Finland.

LTER (http://www.lter-europe.net/, 22.05.2014)

The Long-Term Ecosystem Research (LTER) network is an essential component of world-wide efforts to better understand ecosystems. This comprises their structure, functions, and long-term response to environmental, societal and economic drivers. LTER contributes to the knowledge base informing policy and to the development of management options in response to the Grand Challenges under Global Change. From the beginning (around 2003) the design of LTER-Europe has focussed on the integration of natural sciences and ecosystem research approaches, including the human dimension. LTER-Europe was heavily involved in conceptualizing socio-ecological research (LTSER). As well as LTER Sites, LTER-Europe features LTSER Platforms, acting as test infrastructures for a new generation of ecosystem research across European environmental and socio-economic gradients.

LTER-Europe is a network of:

- National networks and the European contribution to the global International Long Term Ecological Research (ILTER) with over half of the ILTER members belonging to LTER-Europe
- Research infrastructures (LTER sites and LTSER platforms forming national networks)
- Institutions involved in ecological research across the continent and aiming at a virtual European ecological research institute
- Researchers in natural sciences, sociology and economy
- Scientific site co-ordinators and research platform managers
- Long-term data
- Research projects
- Support for communication and lobbying.

FLUXNET (http://fluxnet.ornl.gov/, 22.05.2014)

FLUXNET, a "network of regional networks," coordinates regional and global analysis of observations from micrometeorological tower sites. The flux tower sites use eddy covariance methods to measure the exchanges of carbon dioxide (CO_2), water vapor, and energy between terrestrial ecosystems and the atmosphere. The FLUXNET database contains information about tower location and site characteristics as well as data availability. You can also view the availability of data. The site characteristics and ancillary database may be queried by site. A new Synthesis Activity has been initiated, building on the La Thule 2007 Synthesis.

Lifewatch (http://www.lifewatch.eu/web/guest/home, 22.05.2014)

LifeWatch is the European e-Science infrastructure for biodiversity and ecosystem research meant to provide advanced capabilities for research on the complex biodiversity system. The term 'research infrastructure' refers strategic installation at european/international level supplying facilities, resources and related services to the scientific and other user's communities to conduct top-level activities in their respective field of science. On the top of that, e-Science infrastructures capitalise existing resources and data from physical infrastrutures, distributed centres and signle research groups. The capabilities offered by the LifeWatch, as a e-Science infrastructure, allow users to tackle the big basic questions in biodiversity, as well to address the urgent societal challenges concerning biodiversity, ecosystems and other crosscutting issues.

ICOS (http://www.icos-infrastructure.eu/, 22.05.2014)

Integrated carbon observation system (ICOS) *research* infrastructure

- tracks carbon fluxes in Europe and adjacent regions by monitoring the ecosystems, the atmosphere and the oceans through integrated networks.
- provides the long-term observations required to understand the present state and predict future behavior of the global carbon cycle and greenhouse gas emissions.
- monitors and assesses the effectiveness of carbon sequestration and/or greenhouse gases emission reduction activities on global atmospheric composition levels, including attribution of sources and sinks by region and sector.

NEON (http://www.neoninc.org/about/overview, 22.05.2014)

The National Ecological Observatory Network (NEON) is a continental-scale ecological observation system for examining critical ecological issues.

Enabling a Better Understanding of Continental-Scale Ecology

NEON is designed to gather and synthesize data on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. Data will be collected from 106 sites (60 terrestrial, 36 aquatic and 10 aquatic experimental) across the U.S. (including Alaska, Hawaii and Puerto Rico) using instrument measurements and field sampling. The sites have been strategically selected to represent different regions of vegetation, landforms, climate, and ecosystem performance.

NEON will combine site-based data with remotely sensed data and existing continental-scale data sets (e.g. satellite data) to provide a range of scaled data products that can be used to describe changes in the nation's ecosystem through space and time.

Free and Publicly Accessible Resources:
Continental-scale environmental data
Infrastructure for research (PDF)
Educational tools

NEON's open-access approach to its data and information products will enable scientists, educators, planners, decision makers and the public to map, understand and predict the effects of human activities on ecology and effectively address critical ecological questions and issues.

Current Status of the NEON Project

NEON successfully completed the planning and design phases and entered the construction phase in Spring 2012. NEON is currently building sites. Constructing the entire NEON network will take approximately five years, so NEON expects to be in full operation by approximately 2017. NEON will collect data for 30 years.

Appendix B Sites assessment problem (Francesco della Porta and Francesco Fracaro)

Illustration of from the presentation by Francesco della Porta and Francesco Fracaro (Fondazione Mach) at the AnaEE WP3 meeting in Copenhagen 3-5 February 2014. For simplicity exposition some of the steps described in section 4.7 were not considered in the example.

Step 1-3 – Establish the decision context

The simplified problem outlines the need of prioritizing an upgrade, with 4 candidates sites available for an assessment. The Decision maker is a central body, and the decision could either be definitive or to be considered a reference guideline for inter-country negotiations.

Step 4 - Identify the options to be appraised

Step 5 - Identify objectives and criteria

"Assessing options requires thought about the consequences of the options, for strictly speaking it is those consequences that are being assessed, not the options themselves. Consequences differ in many ways, and those ways that matter because they achieve objectives are referred to as criteria, or attributes. Criteria are specific, measurable objectives. Identifying criteria requires considering the underlying reasons for the organisation's existence, and the core values that the organisation serves"

In this perspective in order to pursue the general objective of supporting research on ecosystem experimentation, 5 criteria were identified as follow:

Experimental Size (hectares)

1. Size of land available for experiments

Technological Capacity (% of criteria met) – This general cluster in the example provided has 2 embedded children criteria:

2. Has cutting edge sensor x,y,z,…
3. Can manipulate factor x,y,z,…

Accessibility (km)

4. How far from airport with regular flights

Analytical Capacity (% of criteria met)

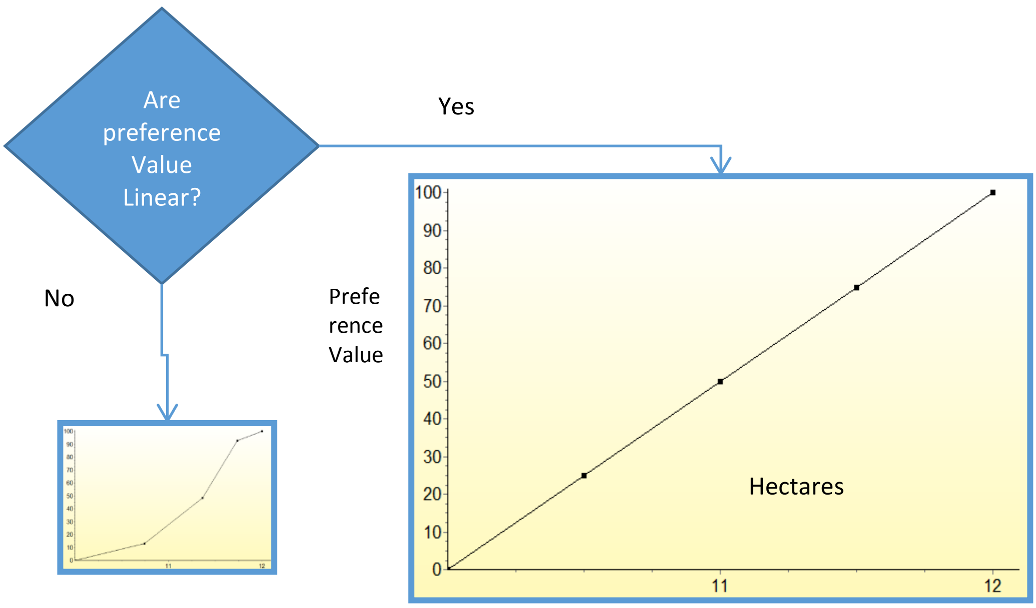
5. Has soil labs, chemical labs, genetic labs, plant handling labs

Step 6 – Score option on the criteria

The simplicity of the example proposed allowed to gather measurements of each option into an excel file. However dedicated software exists to manage more complex problems, such as Hiview and Equity from Catalize Software.

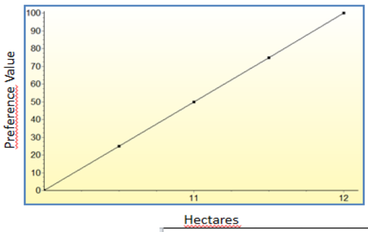
1) assigning measurements to criteria	Criteria							
	Experimental Size (hectares)		Technological Capacity (% of criteria met)		Accessibility (km)		Analytical Capacity (% of criteria met)	
Option	ha	Preference Value	%	Preference Value	km	Preference Value	%	Preference Value
Eifel	10		90%		120		60%	
Hesse	11		80%		30		40%	
Höglwald	11		70%		20		90%	
Klausenleopoldsdorf	12		60%		90		80%	

Even when criteria are assessed by objective/physical measurement, measuring the utility function can take a linear form or a non-linear one. In the first case moving from the worst option available (10 Hectares) to the best (12 Hectares) change the utility linearly from the pre-set anchored level of 0 and 100. A non linear assumption could be instead that for technical constraints, increasing the plot size when 11 Hectares are obtained has no added value. In that case the two intermediate ones might be considered to have equal or only slightly lower utility compared to the best option.



In the case of this example a linear function was adopted:

LINEAR



$$x = \frac{100}{(\text{best} - \text{worst})} * (worst - target)$$

2) assigning value to measurements	Criteria							
	Experimental Size		Technologycal Capacity (% of criteria met)		Accessibility		Analytical Capacity (% of criteria met)	
Option	ha	Preference Value	%	Preference Value	km	Preference Value	%	Preference Value
Eifel	10	0	90%	100	120	0	60%	40
Hesse	11	50	80%	67	30	90	40%	0
Höglwald	11	50	70%	33	20	100	90%	100
Klausenleopoldsdorf	12	100	60%	0	90	30	80%	80
Swing	8		3		100		5	

Step 5 - Weight Criteria

"The reason for weighting is that although options have been scored on individual criteria, criteria scales are not commensurable: a unit of value on one criterion scale is not the same as a unit of value on another scale. Weighting sets the "exchange rates" between the different criteria." (NAO User Manual)

"Weighting in MCDA depends on the concept of swings. A swing is an increase in performance from the level of performance associated with the lower reference point on some criterion to the level of performance associated with the upper reference point. A weight reflects the value of a swing, i.e. the value of improving an option which performs at the lower reference point level on some criterion, so that it performs at the upper reference point level on that criterion. " (NAO User Manual)

Therefore to properly measure swings weights, one cannot consider absolute values of measures separately from the difference of best performance-worst performance. For illustration, focus on one criterion: «Distance from airport», these scenarios of distances from the airport can be considered:

Distance from airport			
Site A	Site B	Difference	Attractiveness
10 km	30 km	20 km	High
10 km	110 km	100 km	Very High
250 km	350 km	100 km	Low
110 km	130 km	20 km	Very Low

absolute values must be considered together, intervals together

It is very important to consider (absolute values + interval) of one criterion together with (absolute values + interval) of the other criteria. For instance, taking the previous example, let's consider distances together with Land Size:

Site A	Site B	Distance Interval	Absolute Importance of distance	Interval in Land Size Site A → Site B	Relative Importance of distance
10 km	30 km	20 km	High	2 ha → 22 ha	Lower!!!
110 km	130 km	20 km	Very Low	2 ha → 2.1 ha	Higher!!!

Conventionally the weight of the most valued swing is set as 1 (or to 100) and the weights of the others wings are set as fractions of the most valued swing. In this perspective swing values were assigned to the criteria.

3) weight criteria	Criteria				Total
Option	Experimental Size	Technologycal Capacity (% of criteria met)	Accessibility	Analytical Capacity (% of criteria met)	
worst performance level	10	0,6	120	40%	
best performance level	12	0,9	20	90%	
swing	10==>12	60%==>90%	120==>20	40%==>90%	
consensus swing weight	20	100	20	75	215
normalized swings weight	0,093	0,465	0,093	0,349	1,00
fair granmother question	is the interval 4 => 22 worth 22% ?	is the interval 6 => 26 worth 40% ?	is the interval 120 => 20 worth 8% ?	is the interval 4 => 9 worth 30% ?	

And subsequently normalized by a simple geometric average:

3) weight criteria	Criteria				Total
Option	Experimental Size	Technologycal Capacity (% of criteria met)	Accessibility	Analytical Capacity (% of criteria met)	
worst performance level	10	0,6	120	40%	
best performance level	12	0,9	20	90%	
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fair granmother question	is the interval 4 => 22 worth 22% ?	is the interval 6 => 26 worth 40% ?	is the interval 120 => 20 worth 8% ?	is the interval 4 => 9 worth 30% ?	

Step 6 – Compute Overall Ranking

Finally each option’s score was weighted with the normalized swing weights and the overall ranking was found, with option 3 (Hoglwald Site) being the most attractive choice:

4) compute overall ranking	Criteria													
	Experimental Size			Technologycal Capacity (% of criteria met)			Accessibility			Analytical Capacity (% of criteria met)				
Option	ha	Preference Value	Weighted Value	%	Preference Value	Weighted Value	km	Preference Value	Weighted Value	%	Preference Value	Weighted Value	Weighted Total	Ranking order
Eifel	10	0	0,00	0,9	100,0	46,51	120	0	0,00	60%	40	13,95	60,47	2
Hesse	11	50	4,65	0,8	66,7	31,01	30	90	8,37	40%	0	0,00	44,03	3
Höglwald	11	50	4,65	0,7	33,3	15,50	20	100	9,30	90%	100	34,88	64,34	1
Klausenleopoldsdorf	12	100	9,30	0,6	0,0	0,00	90	30	2,79	80%	80	27,91	40,00	4